

**MODELING PROTOCOL IN SUPPORT OF
AN EIGHT-HOUR OZONE ATTAINMENT DEMONSTRATION
FOR THE MARICOPA NONATTAINMENT AREA**

Maricopa Association of Governments
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Abbreviations

ADEQ	Arizona Department of Environmental Quality
ADOT	Arizona Department of Transportation
AIRS	Aerometric Information Retrieval System
AZMET	Arizona Meteorological Network
BELD3	Biogenics Emissions Landuse Database, version 3
CAAA	Clean Air Act Amendments of 1990
CAMx	Comprehensive Air-quality Model with Extensions
CBP	County Business Patterns
CMAQ	Community Multi-scale Air Quality model
EPA	U. S. Environmental Protection Agency
EPS3	Emissions Preprocessor System, version 3
FDDA	Four Dimensional Data Assimilation
FSL	Forecast Systems Laboratory
GIS	Geographic Information Systems
I/M	Inspection and Maintenance
LCP	Lambert Conformal Projection
MAG	Maricopa Association of Governments
MAGBEIS3	MAG Modified Biogenic Emission Inventory System, version three
MCAQD	Maricopa County Air Quality Department
MM5	Penn State University/NCAR Mesoscale Model
MOBILE6	EPA-approved Onroad Mobile Source Emissions Model, version six
NAAQS	National Ambient Air Quality Standards
NO _x	Oxides of Nitrogen
NWS	National Weather Service
PRISMS	Phoenix Realtime Instrumentation for Surface Meteorological Studies
RVP	Reid Vapor Pressure
SIP	State Implementation Plan
TSD	Technical Support Document
UAM	Urban Airshed Model
UTM	Universal Transverse Mercator
VOC	Volatile Organic Compounds

1. OVERVIEW OF MODELING STUDY

1.1 Background

Under the 1990 Clean Air Act Amendments, the Maricopa County nonattainment area was initially classified as Moderate for the one-hour ozone National Ambient Air Quality Standards (NAAQS). The area did not achieve the NAAQS for one-hour ozone by the required deadline of November 19, 1996. The one-hour ozone nonattainment area was subsequently reclassified to Serious, effective February 13, 1998. The deadline for Serious areas to attain the one-hour ozone standard was November 19, 1999. There have been no exceedances of the one-hour ozone standard in the nonattainment area since 1996.

The Maricopa Association of Governments (MAG) prepared the One-hour Ozone Redesignation Request and Maintenance Plan which was submitted to EPA in 2004 [3]. EPA subsequently redesignated the Maricopa County one-hour ozone nonattainment area to attainment, effective June 14, 2005; EPA revoked the one-hour ozone standard on June 15, 2005.

On April 30, 2004, EPA published the final rule designating eight-hour ozone nonattainment areas, effective June 15, 2004. A 5,000 square mile area located mainly in Maricopa County and Apache Junction in Pinal County was designated as a nonattainment area for eight-hour ozone. The Maricopa eight-hour ozone nonattainment area is classified as “Basic” under Part D, Subpart I, of the Clean Air Act, with an attainment date of June 15, 2009.

As the designated Regional Air Quality Planning Agency, MAG conducts modeling of emissions and pollutant concentrations and prepares the air quality plans necessary for attainment and maintenance demonstrations in the Maricopa nonattainment area. This protocol is developed to detail and formalize procedures for conducting all phases of the modeling for the eight-hour ozone attainment demonstration.

The primary objective of the study is to determine whether the region will attain the eight-hour ozone standard by June 15, 2009. EPA requires that all control measures necessary to demonstrate attainment be implemented prior to the start of the ozone season preceding the attainment year [13]. To satisfy this requirement, MAG will model the impact of control measures on the attainment of the eight-hour ozone standard during the 2008 ozone season.

A secondary objective of the modeling study is to evaluate the complex chemical relationships between precursor emissions of volatile organic compounds and nitrogen oxides and the formation of ozone. This evaluation will determine if the region qualifies for a NO_x exemption under section 182(f) of the Clean Air Act [11].

Key objectives to be accomplished in this protocol document are to enhance technical credibility, encourage the participation of all interested parties, lay out responsibilities of all participants, provide for consensus-building concerning modeling issues, and provide documentation for technical decisions to be made in applying the models.

The protocol document describes procedures for conducting all phases of the modeling study. These include:

- identifying the background, objectives, tentative schedule, and organizational structure;
- developing the necessary input data bases;
- performing quality assurance and diagnostic model analyses;
- conducting model performance evaluations and interpreting results;
- describing procedures for using the model to demonstrate whether adopted control strategies are sufficient to demonstrate attainment of the eight-hour ozone standard; and
- evaluating the relationships between precursor emissions and ozone formation.

Procedures described in this protocol are intended to foster confidence in the modeling and technical analyses that support the attainment demonstration and request for a NO_x exemption, if warranted.

1.2 Conceptual Model

MAG has conducted an analysis of eight-hour ozone data during the five-year period 2000 through 2004 in order to develop a conceptual model for the eight-hour ozone attainment demonstration. Major features of the conceptual model for the Maricopa nonattainment area are as follows. High ozone concentrations generally occur in May through September, when the weather is hot, covered by clouds, and with stagnant to light winds blowing from the east and southeast. More than 90 percent of high ozone events occur when the daily maximum temperatures are above 90° Fahrenheit (F). High ozone levels tend to occur when dew point temperatures are higher than the average. Most high ozone days occur when a low sea level pressure system resides over southwestern Arizona and a high sea level pressure system occurs over northeastern Arizona.

A detailed conceptual description for each episode is provided in Attachment II, Appendix G. A comparison of the conceptual model with eight-hour ozone modeling results will be included in the Technical Support Document.

1.3 Management Structure and Committees

MAG has responsibilities for regional involvement in a number of planning issues, and has established an extensive mechanism for ensuring coordinated policy direction from elected officials, coordinated management and technical input, advice from the appropriate agency staff, as well as direct citizen input. Figure 1-1 displays the MAG Policy Structure and Figure 1-2 presents the MAG Committee Structure. All policy committees and formal technical committees follow the Arizona open meeting law which requires, among other

requirements, the posting of meeting notices and agendas at least 24 hours prior to any meeting.

The MAG Regional Council is the governing body of MAG. It is comprised of elected officials from each member agency, two ex-officio members representing the Arizona State Transportation Board, and a representative from the Citizens Transportation Oversight Committee. This composition of elected officials is a reflection of citizen input at the local government level. The MAG Regional Council agenda includes a call to the audience, providing the opportunity for public comments at each monthly meeting.

MAG holds at least one formal public meeting prior to the adoption of any new or update to the nonattainment area plan. Formal public meetings are advertised locally at least 30 days prior to the meeting date and documentation is available for public review during this 30-day period. Draft documents are distributed to appropriate federal, state, and local agencies for review and comment during this period. Comments received are analyzed with a staff response for consideration by the MAG Air Quality Technical Advisory Committee and MAG Regional Council before taking approval action. Documentation of the comments and responses are incorporated into the plan document.

Due to the technical complexity of many MAG programs, committees consisting of professional experts are often needed to assist in program development. The Air Quality Technical Advisory Committee is composed of representatives from eight MAG member agencies, citizens, environmental interests, health interests, automobile industry, fuel industry, utilities, public transit, trucking industry, rock products industry, construction firms, housing industry, architecture, agriculture, industry, business, parties to the Air Quality Memorandum of Agreement, and various State and Federal agencies. The role of the Technical Advisory Committee is to review and comment on technical information generated during the planning process and make recommendations to the MAG Management Committee.

1.4 Participating Organizations

Technical oversight for this project will be provided by the Air Quality Planning Team. This team includes staff representatives from the Maricopa Association of Governments (MAG), the Arizona Department of Environmental Quality (ADEQ), the Arizona Department of Transportation (ADOT), and the Maricopa County Air Quality Department (MCAQD). The activities of this working group are directed by a Memorandum of Agreement among the agencies involved (see Attachment I). Representatives of other agencies, including EPA and the U.S. Department of Transportation, will be consulted on technical matters, as needed. The Air Quality Planning Team will meet as necessary during the ozone modeling effort. Periodic reports on the status and progress of various phases of the modeling work will be presented at these meetings, and technical issues will be discussed and resolved.

MAG POLICY STRUCTURE

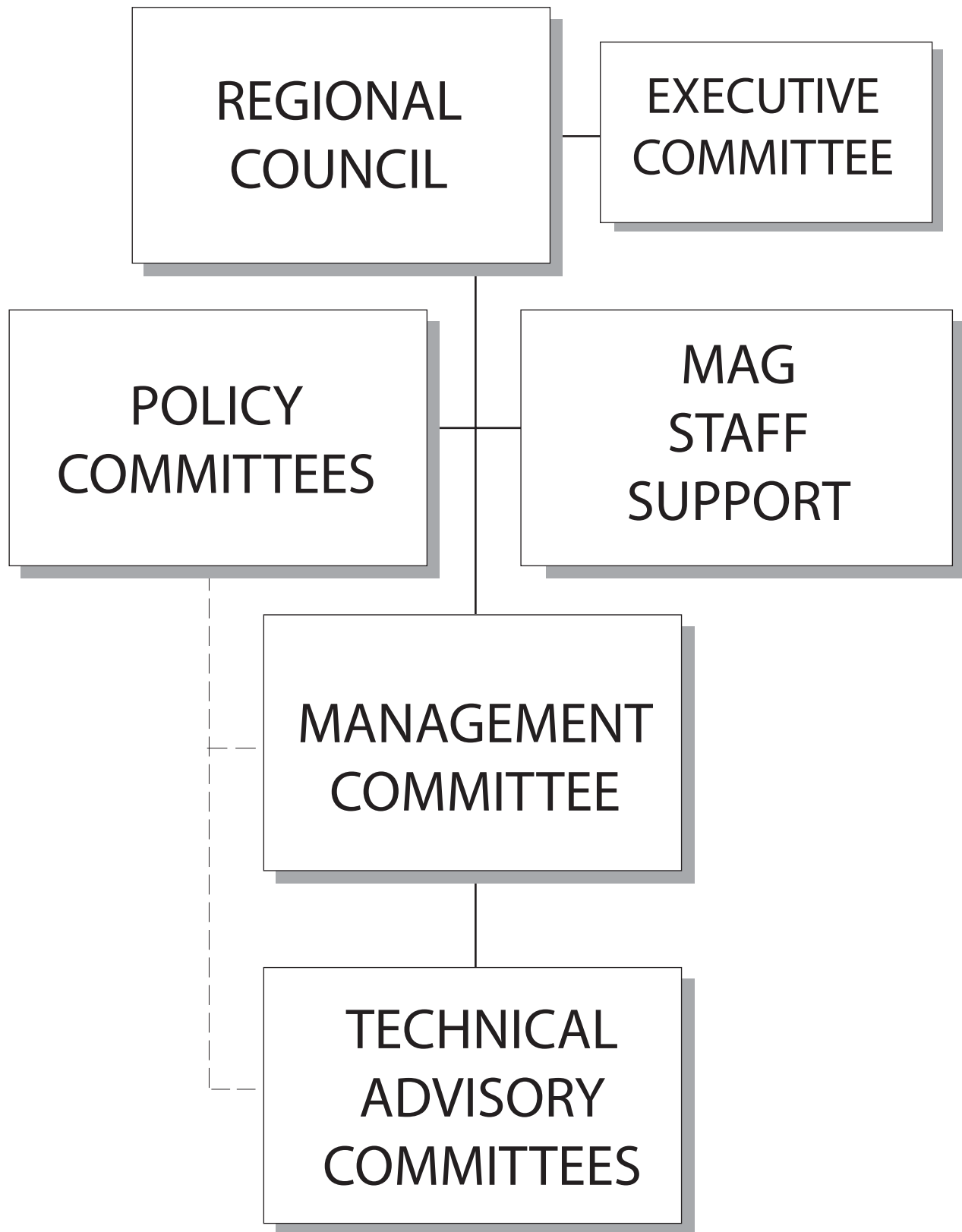


Figure 1-1: MAG Policy Structure

MAG COMMITTEE STRUCTURE

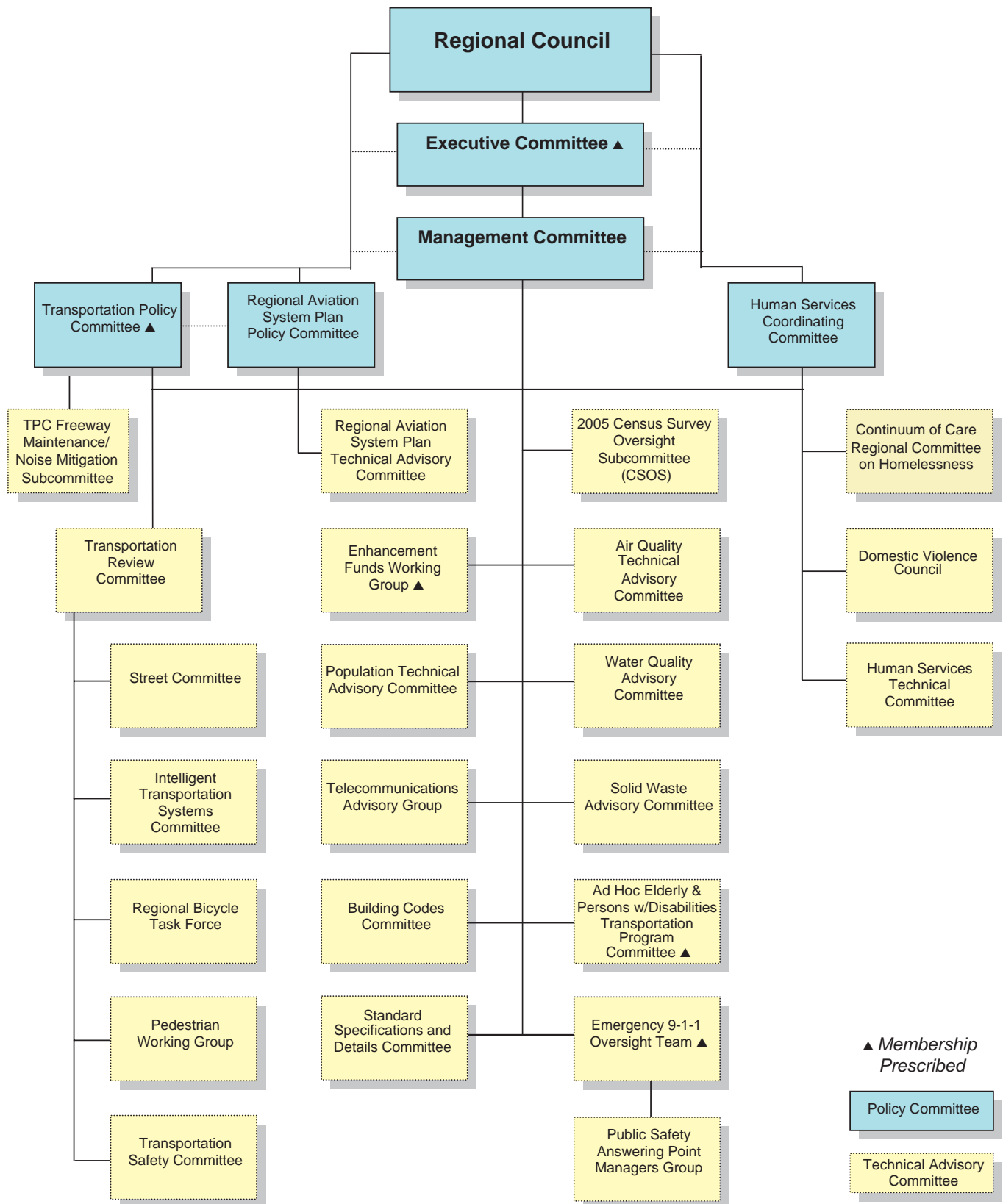


Figure 1-2: MAG Committee Structure

1.5 Schedule

The eight-hour ozone analysis for the Maricopa Nonattainment Area will include the following tasks. The schedule for these tasks is presented graphically in Figure 1-3.

1. Prepare a protocol document (this document) describing the purpose, background, and the procedures to be followed in the remainder of the analysis. This document also specifies the modeling domain and identifies three modeling episodes. (Completion Date: January 31, 2006)
2. The ozone precursor emissions inventory reported in “*2002 Periodic Emissions Inventory for Ozone Precursors*” [6] will be input to the Emission Preprocessor System 3, which will reformat the data into the appropriate CAMx input files for the 2001 and 2002 episodes. (Completion Date: February 28, 2006)
3. Prepare onroad mobile source emissions using MOBILE6 and M6Link for the 2001 and 2002 episode periods. (Completion Date: February 28, 2006)
4. Develop land use, meteorological and air quality inputs for the 2001 and 2002 episode periods. (Completion Date: February 28, 2006)
5. Develop biogenic emissions inventories for 2001 and 2002 using the model recommended by ENVIRON. (Completion Date: June 30, 2006)
6. Run CAMx and evaluate model performance for the 2001 and 2002 episode periods. Select the period with the overall best model performance for modeling the future year. (Completion Date: October 31, 2006).
7. Develop the emissions inventory for 2008. (Completion Date: November 30, 2006)
8. Perform CAMx simulations for 2008. (Completion Date: January 31, 2007)
9. Complete technical analyses and write a technical support document (TSD). (Completion Date: February 28, 2007)
10. Release the Plan and TSD for public review. (Completion Date: March 15, 2007)
11. Make final revisions to the plan and TSD. (Completion Date: April 30, 2007)
12. Submit the plan and TSD to ADEQ/EPA. (Completion Date: May 31, 2007)

Ozone Modeling Task List					2006												2007				
	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Prepare protocol document					★																
Base Year (2001, 2002) Emissions Inventory (EI) preparation						★															
MOBILE6 modeling of 2001 and 2002 onroad mobile emissions						★															
Land use, meteorological and air quality input preparation for episode periods						★															
Biogenic emissions inventory										★											
CAMx modeling and episode performance evaluation														★							
Develop EI for 2008															★						
CAMx simulations for 2008																	★				
Complete analyses and write TSD																		★			
Documents available for public review																			★		
Final revisions																				★	
Submit to ADEQ/EPA																					★

Figure 1-3 Schedule for the Eight-Hour Ozone Attainment Demonstration for the Maricopa Nonattainment Area

2. MODELS AND INPUTS

This Chapter discusses the data and models to be used in simulating meteorology and ozone concentrations. It concludes with a discussion of the quality assurance tests that will be performed to ensure that the air quality, meteorological and emissions inputs to the models are reasonable.

2.1 Rationale for Model Selection

To perform the modeling for the eight-hour ozone attainment demonstration, MAG considered three photochemical dispersion models: the Comprehensive Air-quality Model with Extensions (CAMx), the Community Multi-scale Air Quality (CMAQ) model, and the Variable-grid Urban Airshed Model (UAM-V). EPA has indicated that any of these three models would be appropriate to simulate eight-hour ozone concentrations in urban areas [12]. These models were evaluated according to the selection criteria shown in Table 1-1. A simple scoring system was used for the evaluation; the scores range from 0 to 3, with 0, the lowest score, and 3, the highest.

All three models have been peer-reviewed and are adequately documented[12]. In recent years CAMx and CMAQ have been used more frequently in regulatory applications. EPA used CAMx to model eight-hour ozone in the eastern United states for the Clean Air Interstate Rule (CAIR). CMAQ has been applied by the Western Regional Air Partnership to model visibility in the western United States. EPA has also used CMAQ to model PM-2.5 and visibility for the CAIR.

UAM-V has been applied less frequently than previous versions of UAM. MAG staff had used older versions of UAM to model carbon monoxide, one-hour ozone, and PM-10, but do not have hands-on experience running UAM-V. One MAG staff member has experience using CAMx, and all have either received training or have experience in the application of CMAQ. The UAM-V is the most computationally efficient model, whereas the CMAQ model is the most computationally-intensive. UAM-V is a proprietary model, unlike CAMx and CMAQ.

CAMx accepts emissions in the Universal Transverse Mercator (UTM) coordinate system that the MAG emissions processor (EPS3) utilizes, while CMAQ requires Lambert Conformal Projections (LCP). While conversion from UTM to LCP coordinates can be performed, it reduces spatial accuracy in the modeling process.

The evaluation above suggests that CAMx is the most appropriate photochemical dispersion model for use in the present study. Although CAMx will be the core eight-hour ozone model, MAG also intends to run CMAQ in order to corroborate the air quality modeling results obtained with CAMx.

Table 1-1 Attributes of Candidate Air Quality Models

Selection Criteria	UAM-V	CAMx	CMAQ
Documentation and Track Record	3	3	3
Advanced Technical Features	3	3	3
Recent Applications	1	3	3
Experience of MAG Staff	2	3	3
Computational Efficiency	3	2	1
Flexibility (Proprietary vs. Open Source)	0	3	3
Total	12	17	16

Figure 2-1 depicts the MAG air quality modeling chain with CAMx as the core model. Most of the CAMx input files will be prepared using preprocessor programs. The input files containing information on air quality and meteorology will be based on measured data, where available. The meteorological inputs to CAMx will be prepared using the MM5 model. The Emissions Preprocessor System, EPS3, will be used to process the emissions inventory. The onroad mobile emissions will be generated by the EPA MOBILE6 model and M6Link, a MAG-developed software program that spatially and temporally allocates emissions. More detailed discussions on the preparation of the emissions inventory and meteorological inputs are provided later in this protocol.

2.2 Modeling Domain

Selection of the air quality modeling domains takes into account the eight-hour ozone nonattainment area boundaries, the distribution of major emissions sources, the location of the meteorological and air quality monitoring sites, and the prevailing winds associated with ozone episodes. The CAMx modeling domains are mapped in Figures 2-2 and 2-3. The first map illustrates the inner dispersion modeling domain comprised of 4 km grids. The second shows the spatial relationship between the inner (4 km) and outer (12 km) CAMx modeling domains.

An evaluation of 36-hour back-trajectory air flow patterns was conducted to determine if an even larger CAMx modeling domain, at the 36 km grid resolution, was justified. The evaluation concluded that the outer 12 km CAMx domain shown in Figure 2-3 is of sufficient size to capture transport characteristics for the ozone episodes to be modeled. See Attachment III for details [5]. However, meteorological modeling with MM5 will utilize three nested domains, at 4 km, 12 km, and 36 km grid resolutions, to simulate the selected episode periods. As shown in Figure 2-3, the boundaries of the 4 km and 12 km MM5 modeling domains are larger than the CAMx modeling domains.

The inner CAMx modeling domain encompasses the entire eight-hour ozone nonattainment area and consists of 50 (4 km) grid cells in the west-east direction and 29 (4 km) grid cells in the south-north direction. The origin, at the southwest corner of the inner domain, is located at 297 km easting and 3652 km northing in UTM zone 12. The inner domain has an area of approximately 9,000 square miles.

2.3 Air Quality and Meteorological Data

Air quality and meteorological data to be used in photochemical dispersion modeling will be collected from all valid monitoring sites in the nonattainment area.

2.3.1 Air Quality Data

The Arizona Department of Environmental Quality (ADEQ) and the Maricopa County Air Quality Department (MCAQD) maintain monitoring networks that collect air quality data.

Figure 2-2 The Inner CAMx Modeling Domain

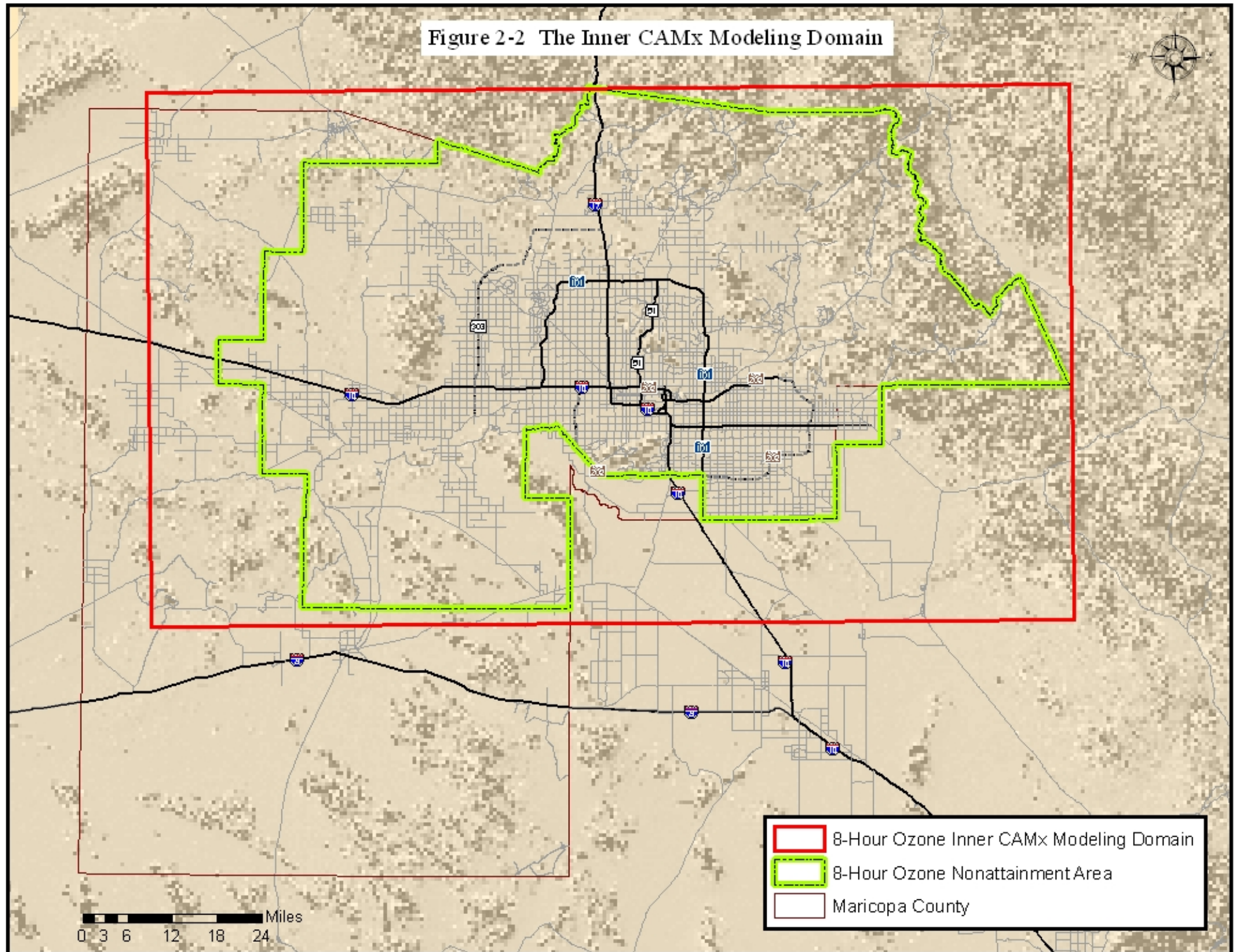
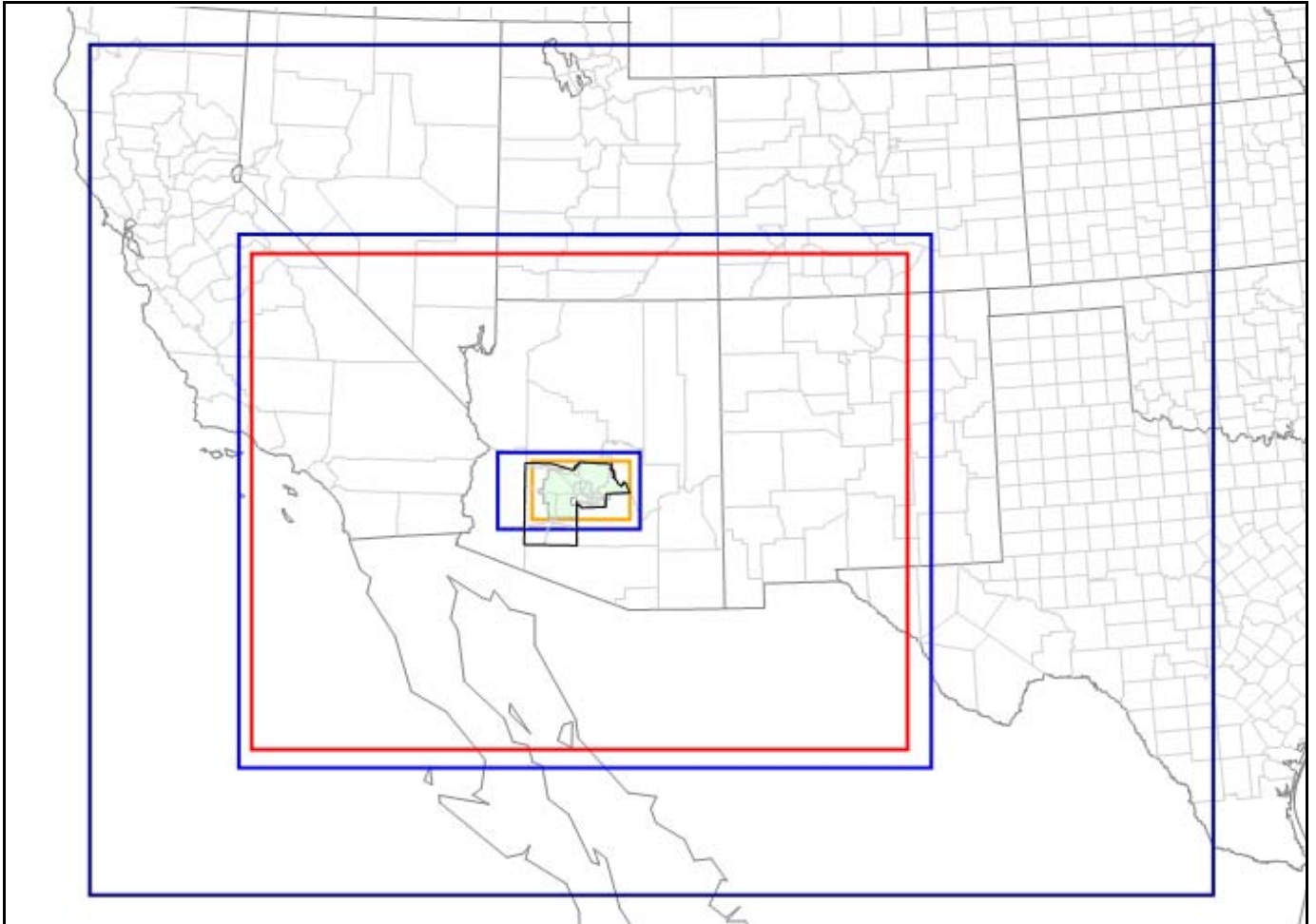


Figure 2-3 Nested CAMx and MM5 Modeling Domains



Two CAMx domains: 12-km grid domain (red) / 4-km grid domain (orange).
Three MM5 domains (blue): 36-km grid domain / 12-km grid domain / 4-km grid domain.
The map projection is UTM Zone 12.

Table 2-1 lists and Figure 2-4 illustrates the locations of the ozone monitoring sites located in the inner CAMx modeling domain. Data from monitoring sites with incomplete data and those sites lying outside the eight-hour ozone nonattainment area were not used in the episode evaluation [4].

Air quality data generally serves two purposes in photochemical dispersion modeling. First, the data are used to specify initial and boundary concentrations. Second, ambient measurements are used to assess the ability of the model to replicate a historical episode, that is, to evaluate model performance for the base case. These topics are addressed in the relevant sections of the modeling protocol below.

2.3.2 Meteorological Data

The air quality networks maintained by ADEQ and MCAQD collect meteorological, as well as air quality data. Additional surface meteorological data have been collected from other monitoring networks including the AriZona METeorological network (AZMET), the National Weather Service (NWS), and the Forecast Systems Laboratory (FSL). Two networks (AZMET and NWS) provide surface observations and the third (FSL) provides upper air data. Table 2-2 identifies the meteorological stations for these three networks. Meteorological data from the Phoenix Realtime Instrumentation for Surface Meteorological Studies (PRISMS) network and the Maricopa County Department of Transportation's ALERT station map will also be evaluated for potential use in meteorological modeling.

The upper air station data for meteorological modeling will be derived from the FSL stations shown in Table 2-2. The stations in Flagstaff, Tucson, and Yuma are located in the outer (12 km) air quality modeling domain. Figure 2-5 illustrates the location of the meteorological monitoring sites. Other valid meteorological data will be applied, as appropriate.

The MM5 meteorological model will be used to generate meteorological inputs, such as horizontal wind components, temperature, pressure, water vapor, vertical diffusivity, clouds and rainfall, in 3-dimensional gridded format. This model incorporates available observations and provides information on terrain-induced air flows in regions where observations are absent. To reduce divergence of the model predictions from actual observations at a particular point in time and space, four dimensional data assimilation (FDDA) will be used with the observational meteorological data.

The modeling domains for MM5 will be larger than the inner and outer dispersion modeling domains, as shown in Figure 2-3. The wind fields for the dispersion model applications will be a subset of the MM5 wind fields. This approach will further diminish the errors propagating from the boundaries to the area of interest.

The mixing depths contained in the MM5 model will be used. Other input variables required as input to CAMx include:

Table 2-1 Ozone Monitoring Sites

Abbr.	Name	AIRS Code	Operator	Location	Data Availability	O ₃	CO	NO	NO ₂	WS/WD
AJ*	Apache Junction	04-021-3001	PCAQD	305 E Superstition Blvd	2002-2004	✓				
BP†*	Blue Point	04-013-9702	MCAQD	Usery Pass & Bush Highway	2000-2004	✓				✓
BE	Buckeye	04-013-4011	MCAQD	26453 W MC85	Since 8/1/2004	✓	✓		✓	✓
CC*	Cave Creek	04-013-4008	MCAQD	37019 N Lavon Ln	Since 8/1/2001	✓				✓
CP†*	Central Phoenix	04-013-3002	MCAQD	1845 E Roosevelt	2000-2004	✓	✓		✓	✓
DY	Dysart	04-013-4010	MCAQD	16825 N Dysart	Since 7/21/2003	✓	✓			✓
EM	Emergency Management	04-013-3004	MCAQD	52nd St & McDowell Rd	Till 5/31/2001	✓				
FF†*	Falcon Field	04-013-1010	MCAQD	4530 E Mckellips	2000-2004	✓				✓
FH†*	Fountain Hills	04-013-9704	MCAQD	16426 E Palisades	2000-2004	✓				✓
GL†*	Glendale	04-013-2001	MCAQD	6000 W Olive	2000-2004	✓	✓			✓
HM†*	Humboldt Mountain	04-013-9508	ADEQ	7 Springs Rd	2000-2004	✓				
LP*	Lake Pleasant	04-013-9805	MCAQD	41402 N 87th Ave	Till 7/31/2001	✓				✓
MRCP**	Maricopa	04-021-3010	PCAQD	44625 W Garvey Rd	Since 7/1/2002	✓				
MV*	Maryvale	04-013-3006	MCAQD	6180 W Encanto	2000-2003	✓	✓			
ME*	Mesa	04-013-1003	MCAQD	370 S Brooks	2000-2002	✓	✓			✓
MORD*	Mount Ord	04-013-9701	ADEQ	Mountain Ord Summit	5/19/2000-2001	✓				✓
NP†*	North Phoenix	04-013-1004	MCAQD	610 E Butler	2000-2004	✓	✓			✓
PALV†*	Palo Verde	04-013-9993	ADEQ	36248 W Elliot Rd	2000-2004	✓		✓	✓	
PP†*	Pinnacle Peak	04-013-2005	MCAQD	25000 Windy Walk Way	2000-2004	✓	✓			✓
QC**	Queen Creek	04-021-3009	PCAQD	301 E Combs Rd	Since 7/1/2002	✓				
QV**	Queen Valley	04-021-8001	ADEQ	10 S Queen Ann	Since 5/23/2001	✓		✓	✓	
RV†*	Rio Verde	04-013-9706	MCAQD	N Forest Rd & Del Ray Ave	2000-2004	✓				
SAC**	Sacaton	04-021-7001	Tribal	35 Pima St	Since 7/1/2002	✓				
SP†*	South Phoenix	04-013-4003	MCAQD	33 W Tamarisk Ave	2000-2004	✓	✓			✓
SS†*	South Scottsdale	04-013-3003	MCAQD	2857 N Miller Road	2000-2004	✓	✓		✓	✓
SUPR†*	Super Site	04-013-9997	ADEQ	4530 N 17th Ave	2000-2004	✓	✓	✓	✓	✓
SU	Surprise	04-013-4007	MCAQD	18600 N Reems Rd	2001-7/14/2003	✓	✓			
TEMP*	Tempe	04-013-4005	MCAQD	1525 S College Ave	Since 7/1/2000	✓	✓		✓	✓
TNM**	Tonto National Monument	04-007-0010	ADEQ	South of SR88	Since 5/24/2002	✓		✓	✓	
WC	West Chandler (old)	04-013-3009	MCAQD	163 S Price Rd	Till 5/31/2000	✓	✓			✓
WC*	West Chandler	04-013-4004	MCAQD	Ellis St & Frye Rd	Since 8/1/2000	✓	✓			✓
WP†*	West Phoenix	04-013-0019	MCAQD	3847 W Earll Rd	2000-2004	✓	✓		✓	✓

† Monitoring sites having a complete data record.

* Monitoring sites having 8-hour ozone exceedance at least once during the period (2000-2004) that affected selection of episodes to be modeled.

** Monitoring sites inside of the inner model domain but outside of the 8-hour ozone nonattainment area. Data from these sites will be used for model performance evaluation.

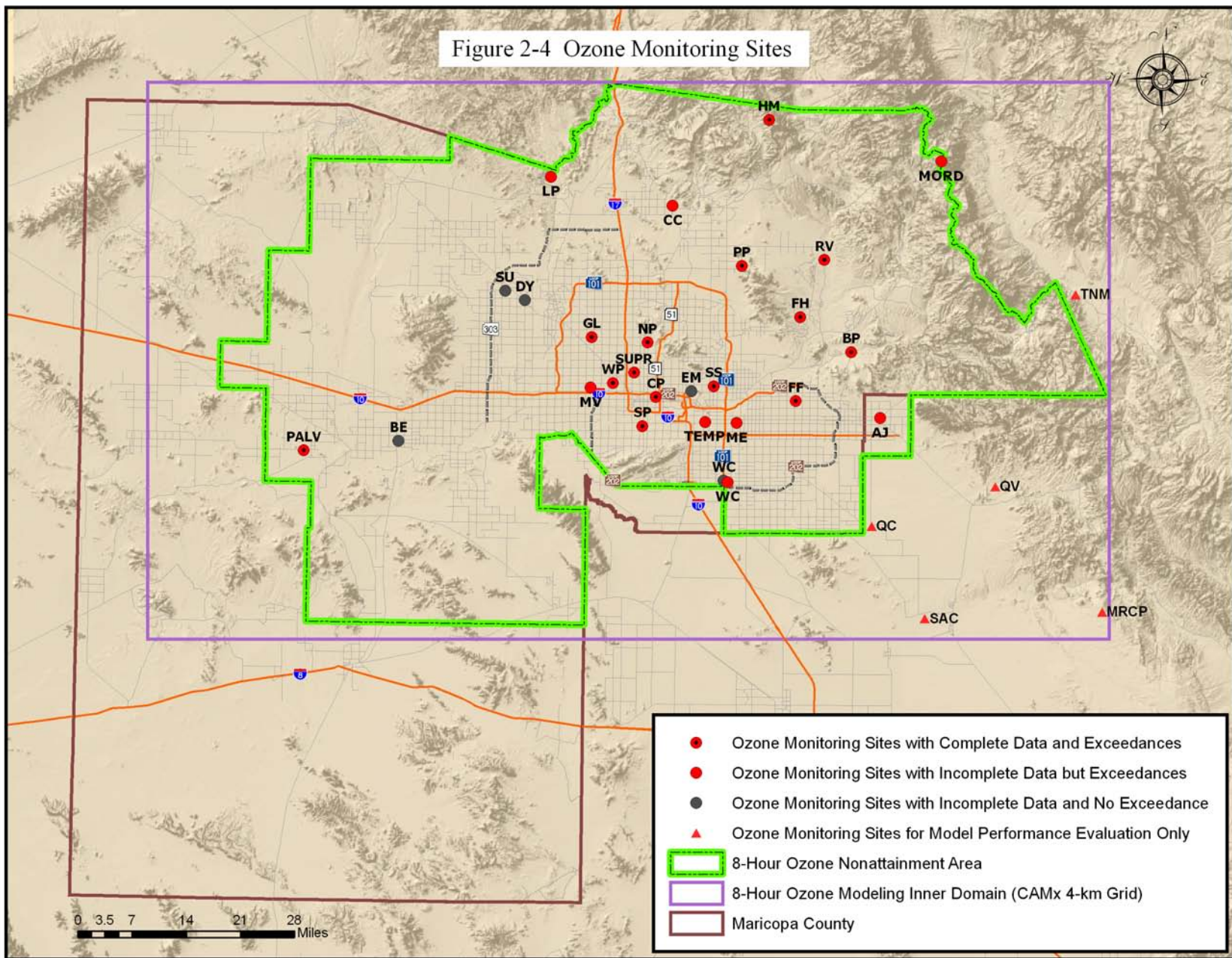


Table 2-2 Meteorological Monitoring Stations

NWS (33 sites)								
Site	Abbr.	Lat	Lon	UTM (Zone 12)		Elev. (m)	Address	County
				Northing (m)	Easting (m)			
Casa Grande Municipal Airport	KCGZ	32.95000	-113.76389	3646004.74	428339.63	446	510 E. FLORENCE BLVD, Casa Grande	Pinal
Chandler Municipal Airport	KCHD	33.26917	-113.93306	3681421.13	424459.38	379	2380 S. STINSON WAY, Chandler	Maricopa
Davis-Monthan Air Force Base	KDMA	32.16667	-111.44806	3558916.01	511000.13	824	DAVIS-MONTHAN AFB, Tucson	Pima
Douglas Bisbee International Airport	KDUG	31.46917	-112.42222	3482443.65	632656.74	1266	1415 MELODY LANE, BLDG C, Douglas Bisbee	Cochise
Phoenix Deer Valley Municipal Airport	KDVT	33.69028	-110.72083	3728325.15	401239.94	450	702 W DEER VALLEY DR, Phoenix	Maricopa
Tucson NEXRAD	KEMX	31.88300	-110.00556	3527531.19	536222.38	1586	Tucson	Pima
Mesa/Falcon Field	KFFZ	33.46667	-109.37917	3703264.45	431857.54	424	4800 FALCON DR, Mesa	Maricopa
Flagstaff	KFGZ	36.21700	-111.67222	4008326.71	426567.23	2192	Flagstaff	Coconino
Libby AAF Fort Huachuca	KFHU	31.60000	-111.81700	3496292.91	563243.03	1438	401 GIULIO CESARE AVE, Sierra Vista	Cochise
Flagstaff Pulliam Airport	KFLG	35.14028	-112.15472	3888806.53	438763.21	2137	6200 S. PULLIAM DR, 204, Flagstaff	Coconino
Flagstaff NEXRAD	KFSX	34.56700	-114.55944	3825044.89	481654.04	2260	Flagstaff	Coconino
Gila Bend U.S. Army Airfield	KGBN	32.43333	-112.68333	3589715.73	341743.08	262	Gila Bend	Maricopa
Grand Canyon National Park Airport	KGCN	35.94611	-110.61700	3978587.39	395854.86	2014	Grand Canyon	Coconino
Glendale Municipal Airport	KGEU	33.52722	-112.38333	3710488.09	379721.07	325	6801 N. GLEN HARBOR BLVD 201, Glendale	Maricopa
Goodyear Municipal	KGYR	33.41667	-110.84583	3698335.76	371380.94	295	1658 SO LITCHFIELD RD, Goodyear	Maricopa
Laughlin/Bullhead International Airport	KIFP	35.15750	-110.33333	3893236.68	722300.40	212	2550 LAUGHLIN VIEW DR, Bullhead City	Mohave
Kingman Airport	KIGM	35.25778	-109.60361	3905575.22	233156.32	1050	7000 FLIGHTLINE DR, Kingman	Mohave
Winslow Municipal Airport	KINW	35.02806	-110.95528	3876190.43	525466.06	1505	21 WILLIAMSON AVE, Winslow	Navajo
Mesa Williams Gateway Airport	KIWA	33.31660	-109.63556	3686574.65	439496.98	421	6001 SOSSAMAN RD, Mesa	Maricopa
Williams AFB/Chandler	KIWA	33.31667	-111.76667	3686574.65	439496.98	421	6001 SOSSAMAN RD, Mesa	Maricopa
Luke Air Force Base/Phoenix	KLUF	33.53333	-111.81111	3711271.17	371553.24	332	LUKE AFB, Glendale	Maricopa
Yuma Marine Corps Air Station	KNYL	32.62361	-109.06667	3612935.22	240675.79	64	Yuma	Yuma
Nogales International Airport	KOLS	31.42083	-111.73333	3476252.27	514652.98	1198	Nogales	Santa Cruz
Page Municipal Airport	KPGA	36.92056	-112.06556	4086153.63	460091.83	1314	697 VISTA AVENUE, Page	Coconino
Phoenix Sky Harbor International Airport	KPHX	33.43417	-111.65000	3699914.60	402291.25	345	3400 SKY HARBOR BLVD, Phoenix	Maricopa
Prescott Love Field	KPRC	34.64917	-111.65000	3835058.29	369663.82	1537	6546 CRYSTAL LANE, Prescott	Yavapai
Wind Rock Airport	KRQE	35.65000	-112.29528	3946850.91	675023.86	2055	Window Rock	Apache
Safford Municipal Airport	KSAD	32.85722	-111.91056	3636283.38	627670.20	968	4550 E AVIATION WAY, Safford	Graham
Scottsdale Airport	KSDL	33.62278	-114.60000	3720703.49	415540.50	460	15000 N AIRPORT DR, Scottsdale	Maricopa
St. Johns Industrial Airpark	KSJN	34.51833	-111.20000	3820822.44	648772.04	1747	St. Johns	Apache
Show Low Regional Airport	KSOW	34.26528	-110.88333	3792017.67	591549.62	1955	3150 AIRPORT LOOP, Show Low	Navajo
Tucson International Airport	KTUS	32.13139	-112.05111	3555000.31	504218.01	805	Tucson	Pima
Yuma International Airport	KYUM	32.65000	-112.38333	3615031.47	725106.73	65	2191 E 32ND ST, Yuma	Yuma

Table 2-2 Meteorological Monitoring Stations (Continued)

AZMET (23 sites)								
Site	Abbr.	Lat	Lon	UTM (Zone 12)		Elev. (m)	Address	County
				Northing (m)	Easting (m)			
Aguila	AGUI	33.946667	-113.188889	3758401	297716	655	0.6 Miles NW of Aguila City Limits	Maricopa
Bonita	BONI	32.463611	-109.929444	3592330	600610	1346	18 Miles N on Rex Allen Dr from Willcox at I-10	Graham
Buckeye	BCK1	33.400000	-112.683333	3696899	343454	304	3.5 km S of Exit 109 from I-10	Maricopa
Coolidge	COOL	32.980000	-111.604722	3649232	443496	422	0.8 km SW of the Curry Rd & Bechtel	Pinal
Eloy	ELOY	32.773889	-111.556944	3626358	447840	461	0.8 km E of 11 Miles Corner Rd on Arica Rd	Pinal
Harquahala	HARQ	33.483333	-113.116667	3706876	303337	350	1.8 km N of the Intersection of Courthouse Rd & 491st Ave	Maricopa
Laveen	LAVE	33.376389	-112.150000	3693605	393027	315	3921 W Baseline Rd	Maricopa
Litchfield	LITC	33.467222	-112.398056	3703959	370087	309	1 Mile N of McDowell Rd on Cotton Ln	Maricopa
Marana	MARA	32.461111	-111.233333	3591572	478071	601	1 Mile W of I-10 on Trico-Marana Rd	Pima
Maricopa	MARI	33.068611	-111.971667	3659313	409299	361	NW corner of field #5 S of Irrigation Lab Building	Pinal
Mohave	MOHA	34.967222	-114.605833	3872026	718581	146	14.2 Miles S of Bullhead City on AZ Route 95	Mohave
Paloma	PALO	32.926667	-112.895556	3644751	322765	219	9 Miles W of Gila Bend on I-8 to Paloma Exit	Maricopa
Parker	PARK	33.882778	-114.447778	3752091	736045	94	8 Miles S of Poston & 0.4 Miles E on Nez Rd	La Paz
Phx. Encanto	ENCA	33.479167	-112.096389	3704947	398135	335	SE of Thomas Rd & 19th Ave (Encanto Golf Course)	Maricopa
Phx. Greenway	PGRN	33.621389	-112.108333	3720728	397193	401	SE of Greenway & 23rd Ave (Cave Creek Golf Course)	Maricopa
Queen Creek	QUEE	33.258333	-111.641667	3680110	440233	430	0.1 km E of Queen Creek Rd & Ellsworth Rd	Maricopa
Roll	ROLL	32.744444	-113.961111	3626837	222539	91	County 4th St & Ave 39 E	Yuma
Safford	SAFF	32.813333	-109.678333	3631367	623729	901	0.8 km SE of Lone Star Rd & Mountain Rd	Graham
Tucson	TUCS	32.280278	-110.945833	3571504	505101	713	1 km NW of Campbell Ave & Roger Rd	Pima
Waddell	WADD	33.618056	-112.459722	3720763	364592	407	2 Miles W of Cotton Ln & 0.4 Miles S of Greenway Rd	Maricopa
Yuma Mesa	YMES	32.611944	-114.633889	3610740	722021	58	0.32 km W of Ave A on 15th St	Yuma
Yuma North Gila	YUMA	32.735278	-114.529444	3624641	731506	44	2.1 km W on 7th Ave from Gila Center	Yuma
Yuma Valley	YVAL	32.712500	-114.705000	3621744	715106	32	5 Miles W of Yuma on 8th St	Yuma
FSL (4 sites)								
Site	Abbr.	Lat	Lon	UTM (Zone 12)		Elev. (m)	Address	County
				Northing (m)	Easting (m)			
Flagstaff/Bellemt	FGZ	35.23	-111.82	3898858	425383	2179	123 miles North from Central Phoenix	Coconino
Tucson	TUS	32.12	-110.93	3553739	506603	788	113 miles South from Central Phoenix	Pima
Yuma/US Army	YUM	32.87	-114.33	3640036	749823	131	138 miles West from Central Phoenix	Yuma
Yuma/US Army	1Y7	32.87	-114.40	3639872	743271	98	142 miles West from Central Phoenix	Yuma

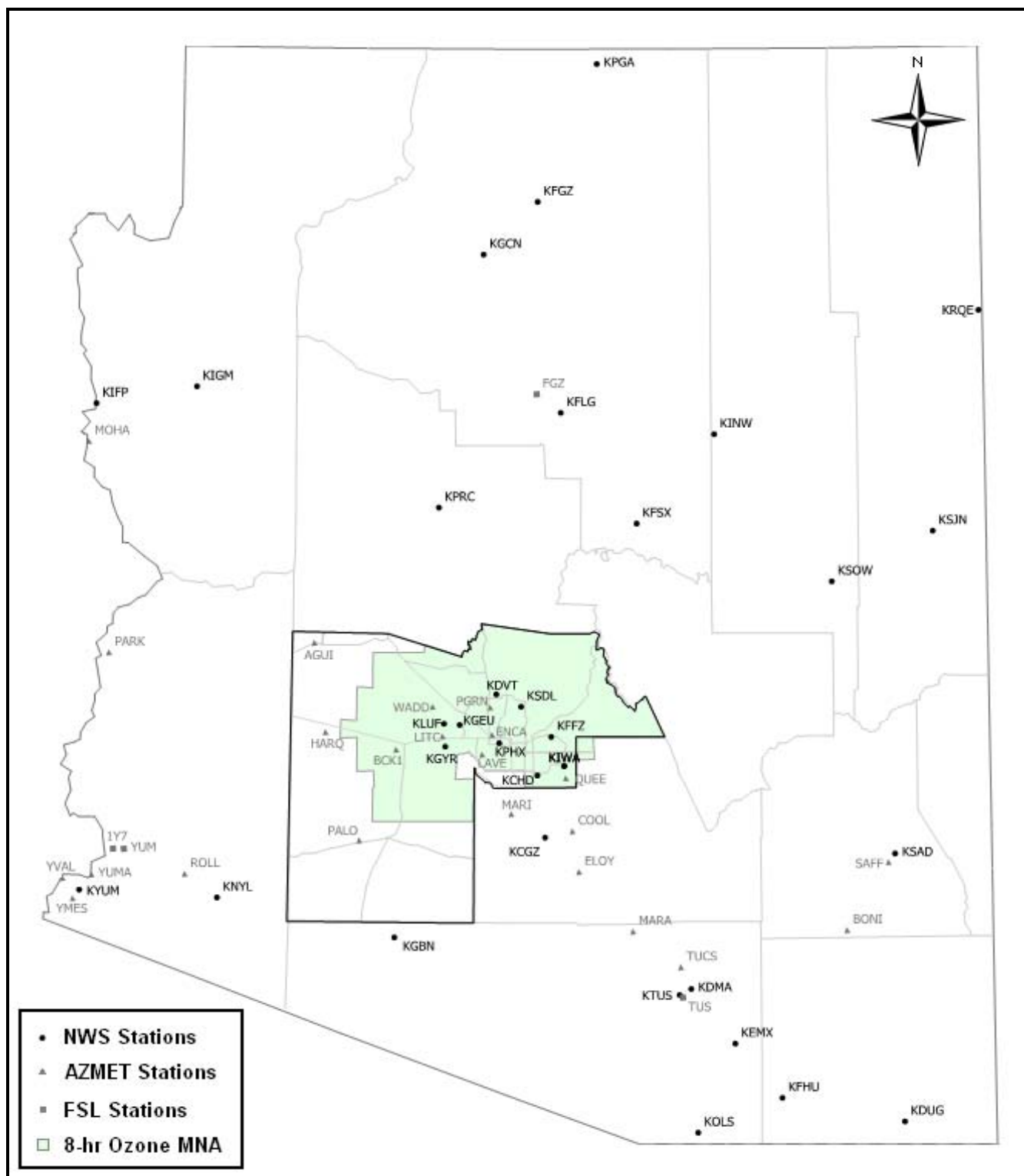


Figure 2-5. Meteorological monitoring stations

- cloud cover,
- water vapor,
- UV radiation,
- surface temperature, terrain, and land use and surface characteristics.

These inputs will be prepared according to locally measured data available for the modeling episodes. Otherwise, the values recommended by EPA will be used in the simulations of eight-hour ozone concentrations.

MAG has contracted with ENVIRON to perform the MM5 meteorological modeling for the three episode periods in 2001 and 2002. ENVIRON will supplement the MM5 meteorological data provided by MAG with data from other sources such as the Western Regional Air Partnership. Using the three nested domains (4/12/36 km grids), ENVIRON will conduct an extensive MM5 performance evaluation using all available measurement data for each episode. Sensitivity and diagnostic runs will be developed to improve model performance in replicating surface and aloft winds, temperature, humidity, boundary layer characterization, and rainfall rates. ENVIRON will recommend to MAG the single best meteorological representation to be used in modeling ozone concentrations for each episode. The MM5 tests and performance evaluation for the three episode periods will be described in the Technical Support Document.

2.4 Vertical Resolution

The number of layers in the vertical direction to be used in the CAMx simulations will be nineteen, fifteen layers within the boundary layer (below 2,500 meters) and four layers above the maximum planetary boundary layer (PBL). The top of the modeling domain will be set at 14,662 meters. The lowest layer in the eight-hour ozone simulation will be 36 meters. This vertical structure is consistent with the MM5 meteorological modeling being performed by ENVIRON for the Western Regional Air Partnership (WRAP) and exceeds the minimum standards recommended by EPA guidance[12].

2.5 Specification of Initial and Boundary Conditions

Air quality data within the 4 km grid modeling domain will be used to derive the initial eight-hour ozone concentrations. A distance-weighted interpolation will be used to generate horizontal gridded initial concentrations for the surface layer. Some pseudo sites at or near the lateral boundaries will be set up in the domain. Background values will be assigned to the 4 km grids based on input from the 12 km grid simulations. Boundary conditions for the 12 km modeling domain will be provided by ENVIRON based on WRAP and CAIR modeling. A constant vertical concentration profile will be specified for each grid column assuming that concentrations were well mixed below the region top of the modeling domain during the first simulation hour.

2.6 Episode Selection

Elevated ozone episodes that occurred during the ozone seasons of the five years, 2000 through 2004, were considered in the selection of episodes for this modeling study. The historical patterns of ozone episodes and the fundamental meteorological regimes conducive to ozone formation in the area were taken into account in evaluating and justifying the selection of episodes. The selected episodes represent three different meteorological regimes that correspond to ozone concentrations of at least 80 ppb. Wind flow patterns (e.g., well defined transport winds vs. light and variable winds) were the primary consideration for distinguishing among regimes. Region-wide temperature observations (e.g., high temperatures vs. less extreme temperatures) were also considered as a factor in selecting the modeling episodes. High ozone days were partitioned into the three major regimes recommended in EPA guidance [12]. The detailed evaluation resulting in episode selection is provided in Attachment II [4].

The primary criteria influencing the selection of the episode periods were:

- The episodes represent a variety of meteorological conditions that frequently correspond with eight-hour ozone exceedances at multiple monitoring sites;
- The episode days have eight-hour ozone concentrations that are close to the design value for each monitor;
- There are adequate emissions, air quality, and meteorological data available for the attainment test for these periods; and
- The selected episodes have a sufficient number of days to base the modeled attainment test on more than one day at each violating monitor.

Three high eight-hour ozone episode periods have been selected based on the detailed analysis described in Attachment II. The three episodes are:

1. July 8-14, 2002 (Regime 1)
2. June 3-7, 2002 (Regime 2)
3. August 5-11, 2001 (Regimes 2 and 3).

The first episode (Regime 1) is characterized by stagnation and locally-generated ozone. It contains the highest 8-hour ozone measured in the Maricopa nonattainment area (MNA) between 2001 and 2004 and includes weekend exceedances. During this period, there were 17 sites with peak ozone concentrations greater than 85 ppb and 8 sites measured their fourth-highest concentrations of the year. This episode ranked the highest of the six candidate episodes that were evaluated.

The second episode (Regime 2) is characterized by higher surface winds, with potential transport mainly from the south and southwest. This episode does not include weekend exceedances. During this period, there were 8 sites with ozone

concentrations above 85 ppb and 9 sites measured their fourth-highest concentrations of the year. This episode ranked third among the six candidates evaluated.

The third episode (Regimes 2 and 3) is characterized by higher surface winds, with both locally generated and transported ozone. It includes weekend ozone exceedances and has 11 sites with concentrations above 85 ppb. This episode was fourth highest among the candidates evaluated.

These three episodes will be modeled in order to reflect the full range of meteorological, transport, and emissions-generation conditions that are characteristic of high ozone days in the MNA. Three spin-up days will be added to each episode, resulting in a total of 28 days to be modeled. Since the episodes occur in 2001 and 2002, emissions inventories will need to be developed for both of these base years.

2.7 Emissions Inventories

The Emissions Preprocessor System (EPS3) will be used to process the emissions inventories. The inventories will consist of emissions from point, area, onroad mobile, nonroad mobile, and biogenic sources. The emissions will be temporally adjusted and spatially allocated in the grid cells using EPS3. EPS3 consists of a set of FORTRAN programs (modules) that are executed sequentially in order to prepare the gridded emissions inventory for use in photochemical dispersion modeling.

The 2001 and 2002 emissions will be adjusted to be consistent with the meteorological conditions during the selected episode periods. The resulting episode period emissions will also be adjusted to reflect control programs and activity levels prevailing during the days and years modeled. These adjustments will result in different modeling inventories for each of the 2001 and 2002 base case ozone episodes.

The base case modeling inventory for 2002 will be adjusted to reflect emissions expected to occur in 2008. The general methodology for creating the 2008 base case emissions will be based on EPA guidance on the preparation of emissions projections [9]. This adjustment will entail the use of growth factors, ongoing control programs, and retirement rates for obsolete sources of emissions.

The growth factors used to create the 2008 inventory for area and onroad mobile sources will reflect the latest socioeconomic projections based on the 2000 Census. It is anticipated that new socioeconomic projections will be approved by the MAG Regional Council in mid-2006.

The modeling inventories for the 2001 and 2002 base cases and the 2008 future year will reflect the impact of the committed control measures, where appropriate. The 2008 emissions inventory, reflecting the worst case episode period selected from among the three base cases, will be used to demonstrate the modeled attainment status.

Table 2-3 summarizes the daily ozone precursor emissions for the five major source categories during the 2002 ozone season in Maricopa County. The assumptions to be used in estimating emissions for each of these source categories are discussed in more detail below.

2.7.1 Consistency With Periodic Emissions Inventories

The CAAA of 1990 requires that periodic inventories of ozone precursor emissions be prepared at three-year intervals for ozone nonattainment areas. The 2002 periodic inventory was prepared by MCAQD in June 2004 [6].

The Technical Support Document (TSD) for the eight-hour ozone attainment demonstration will describe how the point and area source emissions used in the modeling were derived from the 2002 periodic emissions inventory. The TSD will also explain and justify the differences between the 2002 base case onroad, nonroad, and biogenics emissions and the 2002 periodic emissions inventory. If Maricopa County and Pinal County have completed the 2005 periodic inventory of ozone precursor emissions by January 2007, a comparison of the 2002 base case and 2005 periodic emissions inventories will also be documented in the TSD.

2.7.2 Treatment of Point and Area Source Emissions

The 2002 point and area source emissions will be derived from the 2002 periodic inventories of ozone precursor emissions developed by the Maricopa County Air Quality Department (MCAQD) and the Pinal County Air Quality Control District (PCAQCD). MAG will work with MCAQD and PCAQCD to develop the factors needed to derive 2001 and 2008 point and area source emissions from the 2002 periodic inventories.

2.7.3 Treatment of Mobile Source Emissions

On January 29, 2002, EPA announced the official release of the MOBILE6 model for regulatory use outside of California. MOBILE6.2 is the latest update of the onroad mobile source model developed by EPA to estimate vehicle emission factors. The onroad mobile source emissions for the eight-hour ozone attainment demonstration will be developed using the MOBILE6.2 model. It should be noted that the onroad mobile source portion of the 2002 periodic inventory for ozone precursors [6] was also developed using the MOBILE6.2 model. However, onroad mobile source emissions will be re-estimated for this analysis using the latest socioeconomic data and transportation system assumptions available in mid-2006.

MOBILE6.2 uses a variety of inputs. Each modeled scenario will require at least ten runs: a minimum of one Inspection and Maintenance (I/M) run and a non-I/M run for each of the five area types included in the transportation modeling area: central business district, urban, urban fringe, suburban, and rural. The results from these runs will be weighted appropriately to reflect the actual proportions of I/M and non I/M

Table 2-3 2002 Daily Ozone Season Emissions in Maricopa County [6]

	VOC		NOx		CO	
	lbs/day	%	lbs/day	%	lbs/day	%
Area	315976	33.16	61570	8.08	1706230	31.36
Nonroad Mobile	116432	12.22	165466	21.70	1698871	31.23
Onroad Mobile	180380	18.93	437741	57.42	2023444	37.19
Biogenic	309511	32.48	71648	9.40	NA	NA
Point	30728	3.22	25938	3.40	12130	0.22
Total	953027	100.00	762363	100.00	5440675	100.00

vehicles within the nonattainment area. In addition, the inputs for each run will include Reid Vapor Pressure (RVP), oxygen, and sulfur gasoline content values appropriate for the summer ozone season. The temperature range will reflect episode day conditions in the nonattainment area for the episode chosen. Note that these values will vary depending upon the episode period being modeled. The 2008 committed measure package runs will reflect control measure assumptions for the pertinent commitments contained in the MAG Serious Area Plans for PM-10 and CO [1,2], and the One-Hour Ozone Maintenance Plan [3], where appropriate.

MOBILE6.2 generates emission factors which incorporate local vehicle speeds, episodic temperatures, and hot/cold operating modes. These emission factors will be utilized by the M6Link system to estimate onroad mobile source vehicle emissions for the inner modeling domain.

The M6Link system is a FORTRAN-based set of programs (M6Link1 and M6Link2) that are applied at the regional level to examine transportation and related air quality issues. The system is designed to read in files created by the MAG EMME/2 transportation models, and extract the relevant data needed for an air quality analysis, including data needed to run the MOBILE6.2 model. The M6Link1 extracts data such as roadway link speeds, locations, and vehicle miles of travel (VMT) and assigns link VMT to the correct hour and air quality grid cell accordingly. M6Link1 also factors link VMT to be consistent with Highway Performance Monitoring System VMT by functional system.

The MOBILE6.2 program is run using the output from M6Link1 as part of its input data. The output from MOBILE6.2 is then used as one of the inputs to M6Link2, the second program of the M6Link system. M6Link2 combines the output from M6Link1 and the output of MOBILE6.2 to produce hourly gridded emissions, suitable for input to the photochemical dispersion model. These results incorporate locally-derived hourly VMT splits, vehicle speed data, VMT by four vehicle classes by area and roadway type, fuel characteristics, and temperatures, to ensure results appropriate to episode conditions.

In addition to CAMx-ready files, M6Link2 produces tables summarizing VMT and vehicle hours traveled (VHT) by facility type and area type. Also, tables summarizing emissions totals by hour, facility type, or emissions source (i.e. exhaust vs. evaporative) are produced. EPS3 will be used to combine the M6Link output with the emissions of other source categories (e.g., point, area, and biogenic emissions) to create the emissions file used by the photochemical dispersion model.

2.7.4 Treatment of Nonroad Mobile Emissions

MAG will use the Draft 2004 EPA NONROAD model to estimate ozone precursor emissions for all nonroad mobile sources, except aircraft and ground support equipment. Maricopa and Pinal County Business Patterns (CBP) data will be used to estimate 2001 and 2002 activity data that is input to the NONROAD model. Growth factors to forecast 2008 nonroad emissions for all sources except aviation will be based

on EPA default assumptions in the NONROAD model, unless other data (i.e., MAG socioeconomic projections, WRAP growth factors) prove to be more representative of local conditions.

Locomotive emissions will be estimated using activity data provided by the Union Pacific and the Burlington Northern Santa Fe Railroads. Base case and forecast year activity data for aircraft and ground support equipment will be derived from recent airport surveys. Aircraft emission factors used in the MAG Aviation Preprocessor will be obtained from the International Civil Aviation Organization Engine Exhaust Emissions Data Bank.

2.7.5 Location of Anthropogenic Emissions

The locations of power plants in Maricopa County are provided in Table 2-4. The locations of emissions from other human activities are shown in the one-hour ozone emission density plots contained in Attachment IV [3]. The density plots show the distribution of onroad mobile source and background emissions of NO_x and VOC for the one-hour ozone modeling domain during the episode period in August 1999. Background emissions include point, area and nonroad sources, but exclude onroad and biogenic sources.

2.7.6 Treatment of Biogenic Emissions

The biogenic emissions model allows hydrocarbons emitted by vegetation and NO_x emitted by soil to be included in the emissions inventory. MAG has contracted with ENVIRON to recommend a biogenic emissions model and biogenic emission rates appropriate for vegetation and soils in the Maricopa nonattainment area. These recommendations will be used to prepare the biogenic emissions inventory for the eight-hour ozone attainment demonstration.

The recommended biogenics emissions model will use local land use data and gridded hourly temperature data to calculate emissions of VOCs and NO_x in each grid cell of the modeling domain for each hour of the modeling period. The most recent land use data compiled by MAG for transportation and planning purposes will be used in spatially allocated the biogenic emissions. Procedures for development of the biogenic emissions will be documented in the TSD. The biogenic emissions will be generated in CAMx-ready format and will be merged with the other emissions input files.

2.7.7 Temporal Allocation of Emissions

Emissions in the 2002 periodic inventory for ozone precursors [6] are provided either as annual averages or as daily ozone season values, except for peaking power plants. Emissions from the peaking power plants for modeling purposes will be based on the actual operating schedule provided by MCAQD. Typical peak ozone season day

Table 2-4. Power Plants in Maricopa County

Power Plant	Location	City	UTM (Zone 12, m)	
			Easting	Northing
APS West Phoenix Power Plant	Hadley St.	Phoenix	392414	3701190
Duke Energy Arlington Valley	Elliot Rd.	Arlington	323858	3691307
New Harquahala Generating Co.	491 st Ave.	Tonopah	303688	3705787
Mesquite Generating Station	Elliot Rd.	Arlington	326602	3691016
Ocotillo Power Plant	University Dr.	Tempe	415224	3698573
Palo Verde Nuclear Generating Station	Wintersburg Rd.	Tonopah	325615	3696527
Gila River Power Station	Watermelon Rd.	Gila Bend	341737	3649850
Redhawk Generating Station (Pinnacle)	363rd Ave.	Arlington	328940	3690200
Santan Generating Plant	Val Vista Dr.	Gilbert	430407	3688183
SRP Agua Fria Generating Station	Northern Ave.	Glendale	387108	3713387
SRP Kyrene Steam Plant	Kyrene Rd.	Tempe	412877	3691004

emissions correspond to an average weekday during the summer season, defined as July through September in the 2002 periodic inventory. To convert these values to average episode day values in 2001 or 2002, EPS3 will apply an adjustment factor representing the ratio of the episode day emissions to average summer emissions for each source type in the appropriate year.

All point sources, except peaking power plants, and area, nonroad mobile, and aviation sources, will be resolved temporally based on profiles for seasonal activity, activity provided by day of week, and diurnal patterns of activity. EPS3 will be used to convert to episode period values by applying monthly and day-of-week adjustment factors. For the 2008 forecast year, the point sources defined in the 2002 periodic inventory will be allocated according to projected operating schedule data, where available.

2.7.8 Spatial Allocation of Emissions

Point sources will be spatially allocated according to the coordinates (i.e., UTM) of each source. The latest projections based on the data from the 2000 U. S. Census, appropriate land use data, and general plan data will be used for the spatial allocation of area and nonroad mobile sources. The MAG transportation models will assign travel to 2001, 2002 and 2008 highway networks that will be used to spatially distribute onroad mobile source emissions. Biogenics emissions will be allocated spatially using the MAG 2004 land use cover for the urbanized portion of Maricopa County and the EPA Biogenic Emissions Landuse Database (BELD3) for the remainder of the modeling domain.

2.7.9 Treatment of SIP Control Measures

The base and future year emissions inventories will include the committed measures, where appropriate, from the Revised MAG 1999 Serious Area Carbon Monoxide Plan [2]; the Revised MAG 1999 Serious Area Particulate Plan for PM-10 [1]; and the MAG One-hour Ozone Redesignation Request and Maintenance Plan [3], to determine if the committed measures are sufficient to demonstrate attainment of the standard. If the modeling outlined in this protocol does not demonstrate attainment of the standard with the existing committed control measures, the technical support document will be revised to document any additional measures that will be necessary to attain the standard.

2.8 Quality Assurance

The purpose of quality assurance testing is to establish that apparently good model performance is the result of valid model inputs and assumptions, and not the result of compensating errors in input data. Prior to conducting a base case simulation, individual air quality, meteorological, and emissions data components will be reviewed for consistency and obvious omission errors. Both spatial and temporal characteristics of the data will be evaluated. Examples of component testing include:

- **Air Quality:** Check for correct order of magnitude; compare values with monitored data; assure reasonable speciation.
- **Emissions:** The emissions inventory will be tabulated, plotted, and examined. The quality assurance procedures will include documentation of major assumptions, careful accounting of emissions totals throughout the development process, verification of spatial distribution of emissions against known source locations and emission strengths, and identification of missing or unreasonable data values.
- **Meteorology:** If data are available, plot surface and elevated wind vectors and compare with monitoring stations and weather maps for consistent patterns; compare mixing height fields with sounding data; check temperature fields.

It is very important to perform the quality assurance tests prior to performing model simulations. Errors uncovered by the quality assurance testing of component input fields might be extremely difficult to diagnose later in the modeling process where errors could arise from any subset of the data inputs.

3. MODEL PERFORMANCE EVALUATION

This chapter discusses the procedures to be followed for diagnostic testing of the base case episode. The purpose of the diagnostic tests is to uncover potential data input gaps that, when corrected, lead to improved model results. The evaluation increases confidence in the ability of the model to capture key meteorological features in order to predict future ozone concentration levels.

3.1 Diagnostic Tests

After conducting the above quality assurance tests, CAMx will be run for the base case episode. Emphasis will be placed on correctly depicting the regional distribution and timing of observed ozone concentrations. Spatial and time series plots will be used to assess model behavior.

To aid the interpretation of simulation results, predicted and observed ozone concentration maps will be constructed for each base case episode. Concentration maps present spatial information on the structure of the ozone plume. Maps at eight hour intervals will be constructed over periods of the ozone plume and over periods of most interest. While a typical period might be defined as early morning to late afternoon for the day of the highest ozone concentration, it is useful to look at most time intervals under recirculation, stagnation, and transport conditions.

Consideration will also be given to constructing a map which depicts the highest predicted daily eight-hour ozone value for each grid cell. Examples of representative mapping techniques are described in Tesche, et. al. [13] The predicted concentration to be used in the time-series plots will be defined using the same method for deriving predicted concentrations for the model performance evaluation. This method consists

of a four-cell weighted average using bilinear interpolation of the predictions from the nearest four grid cells to the monitor location [13].

If feasible, time-series plots will be developed for NO_x, as well as for VOC species at selected locations, particularly for cases in which ozone time-series or mapping results do not appear consistent with expectations. Comparisons of calculated ozone precursor concentrations with any available observations will be done for concentration levels above the detection limits of the monitoring equipment.

Additional diagnostic tests for the base case will be performed depending upon the availability of time and resources. A number of sensitivity tests will be conducted with CAMx to determine the response in ozone concentrations to changes in key inputs such as emissions and mixing depth. The sensitivity simulations could include one or more of the following:

Zero Boundary Conditions. Inflow concentrations at the lateral boundaries and top of the modeling domain will be reduced to zero. Sensitivity of the concentrations in the inner core and downwind portions of the modeling domain provide a measure of the influence of the boundary conditions. This simulation will provide assurance that the upwind extent of the domain is adequate.

Zero Initial Conditions. Initial concentrations for all grid cells will be reduced to zero. Sensitivity of concentrations within the modeling domain provide a measure of the influence of the initial conditions. Changes of less than a few percent indicate that the initial conditions are not dominating concentration estimates within the domain.

Diffusion Break Heights. Diffusion break heights will be doubled for one simulation and halved for another. Sensitivity of the concentrations within the modeling domain provide a measure of the influence of diffusion break heights. These simulations will provide assurance that the diffusion break heights are adequate.

More elaborate diagnostic tests involve sensitivity-uncertainty studies that examine model responses to a range of variation in input parameters (i.e., various changes in emission levels, emission speciation, etc.) All diagnostic steps will be documented to avoid misinterpretation of model performance results. Once confidence is gained that the simulation is based on reasonable interpretations of observed data, and model concentrations generally track, spatially and temporally, known urban plumes, a performance evaluation based on numerical measures will be conducted for each base case episode.

As part of the diagnostic tests, considerable effort will be expended to investigate the nature of the photochemical interaction between VOC and NO_x and the formation/titration of ozone. The diagnostic tools available in CAMx will be applied to determine if all or a portion of the MNA is VOC-limited in 2008.

3.2 Test Results/Input Modifications

Following the diagnostic modeling analyses, the simulation results will be carefully examined for possible modification or refinement of the input components. On a case-by-case basis, the performance of CAMx for each base case simulation will be evaluated to determine whether or not it is acceptable, with or without input modifications. The model performance criteria listed in the EPA guidance [12], and supplemental analyses presented in the next chapter (Chapter 4), will be used in the evaluation.

3.3 Performance Evaluation Goals

Simulated and observed eight-hour average ozone concentrations at each monitoring station will be utilized in setting statistical performance goals. Some general model performance guidelines have been outlined in the EPA guidance [12]. Among the general guidelines are the following statistical performance goals:

Unpaired highest-prediction accuracy - percentage difference between domain wide simulated and observed peak unpaired in space or time. EPA recommended range: $\pm 20\%$.

Normalized bias test - provides a measure of the ability of the model to replicate observed patterns during the times of day when available monitoring and modeled data are most likely to represent similar spatial scales. EPA recommended range: $\pm 15\%$.

Gross error of all pairs above 80 ppb - in conjunction with bias, this metric provides an overall assessment of base case performance and may be used as a reference to other modeling applications. Gross error may be interpreted as precision. EPA recommended range: $\pm 35\%$.

In general, performance measures that fall within or below these ranges would be considered acceptable. However, results from the above three statistical measures alone may not be sufficient to fully assess the capability of the model in reproducing the chemical and physical processes governing urban-scale ozone concentrations. Therefore, the model performance evaluation procedures will be expanded to include additional numerical and graphical measures recommended by Tesche, et. al. [13]

The additional seven numerical measures include temporally and spatially paired peak estimates, temporally or spatially paired peak estimates, average station peak estimates, bias and gross error, and variance. The additional graphical measures include time series plots and "spatial" time series plots, time series displaying highest and lowest estimates by sites, ground level isopleths, and scatter plots of estimates and observations.

If the statistical results do not meet the recommended performance criteria, and graphical analyses also indicate poor model performance, an alternative episode will be chosen or the EPA regional office will be contacted for review and approval of the base case episode before any future-year simulations are undertaken.

4. ATTAINMENT DEMONSTRATION

4.1 Identification of Attainment Year

The primary purpose of conducting regional modeling with CAMx is to demonstrate attainment of the NAAQS for eight-hour ozone by June 15, 2009. To ensure that all control measures necessary to show attainment are in place by the beginning of the ozone season in 2009, EPA requires that the ozone season in the previous year, 2008, be modeled.

4.2 Identification of Control Measures

The committed control measures already implemented in the Serious Area CO Plan, the Serious Area PM-10 Plan and the One-hour Ozone Maintenance Plan will be evaluated. If additional control measures are needed, they will be submitted to the MAG Air Quality Technical Advisory Committee for consideration as part of the Suggested List of Measures. Following Regional Council approval of the Suggested List of Measures, the local jurisdictions and the Legislature will be requested to consider the implementation of the measures under their respective authorities. Each jurisdiction determines which measures are feasible for implementation by that jurisdiction. These measures then become the committed measures. The committed control measure package will be incorporated into the emissions inventory for CAMx. Based upon the results of these simulations, it will be determined if the control strategies demonstrate attainment of the eight-hour ozone standard.

If additional control measures are needed, the procedures for selecting the control strategy scenarios will conform to the State Implementation Plans (SIPs) [1,2,3], follow current EPA guidance [12] or any deviation from the guidance will be fully justified, and incorporate our present understanding of the urban/regional ozone problem. The 2008 runs will reflect control measure assumptions for the commitments contained in the SIPs [1,2,3], where appropriate.

4.3 Modeled Attainment Test

To demonstrate attainment of the eight-hour ozone standard in 2008, the future design values near each monitor should not exceed 84 ppb. The future design values will be predicted by multiplying a relative reduction factor (RRF) by the base case monitored design value at each site [12]. The RRF is the ratio of the CAMx-modeled future to base case 8-hour daily maximum concentrations predicted near a monitor (averaged over several days).

“Near a monitor” means within approximately 15 km of each site [12]. In the case of 4 km grid cells, EPA recommends that an array of 7 x 7 grid cells, with the monitor located in the center grid, be considered “near a monitor.” Initially, MAG will utilize a 7 x 7 grid cell array to demonstrate attainment near each monitor. If CAMx modeling reveals that the MNA is VOC-limited, the size of the array may have to be altered to avoid RRFs that are unrealistically large or small. Any deviation from the 7 x 7 grid array will be justified in the TSD.

The highest eight-hour ozone maximum predicted by CAMx in the grid cells near a monitor will be computed for each day in the episode period (except initialization days). These daily values will be averaged over the number of days in the episode to obtain the future and base case concentrations used in calculating the RRFs. Predicted base case maxima below 70 ppb will be excluded from the analysis.

The 2002 design value for each monitor will be calculated as the average of the current design values for the periods: 2000-2002, 2001-2003, and 2002-2004. Similarly, the 2001 monitored design values will be calculated as the average of the current design value for the periods: 1999-2001, 2000-2002, and 2001-2003. The current design value for each period is defined as the three year average of the fourth highest daily 8-hour maximum ozone concentration monitored at each site.

The modeled attainment test will be performed for the episode period [4] that represents worst case conditions. Additional tests that may be performed are described in the next Chapter.

4.4 Modeling Reliability and Uncertainties

CAMx is considered to be an appropriate tool for projecting the future air quality impact of changes in emissions [12]. However, future year modeling results should not be considered absolute guarantees of future air quality. Uncertainties in the models used and their inputs, along with meteorological variability, may result in actual future air quality that differs from predicted air quality. Higher concentrations than those modeled may occur for any of the following reasons:

Meteorological variability - In selecting a modeling episode, the goal is to select periods that represent worst-case conditions. If episodes with more severe stagnation occur in the future, emission controls designed to reach attainment for a historical episode may not be adequate.

Emissions variability - Emission estimates are based on average source usage, taking into account seasonal, diurnal, and day-of-week factors. Nonroad and onroad mobile emissions estimates take into account day-specific temperatures as well. However, emissions on a given day may be greater than average due to greater than average usage, lower temperatures, or other factors.

Uncertainty in growth projections - If growth projections underestimate true growth rates, future year emissions may be greater than projected emissions.

Uncertainty in control measure effectiveness - If actual emission reductions from a given control measure are smaller than the estimated emission reductions, future concentration will be greater than modeled concentrations.

Model performance - If the model under-predicted concentrations at a particular site, or has failed to capture a particular aspect of the meteorology, then a level of emission reduction that appeared to be adequate during modeling may not actually be adequate.

By similar reasoning, future measured concentrations may be lower than modeled concentrations because of these variabilities and uncertainties. In addition, future measured concentrations will still be limited to monitoring site locations.

As a result, although modeled future design values below 85 ppb are adequate to demonstrate attainment, modeling results are better thought of as points on a probability distribution. If the modeled peak values are below 80 ppb, the probability that attainment will result, even under differing conditions, is high. If the modeled peak is very close to 85 ppb, however, the probability that attainment will result may be well below 100 percent given the probabilistic nature of meteorology and modeling.

The relative reduction factor approach recently introduced by EPA [12] uses average values (modeled and monitored) that are more likely to result in an accurate assessment of attainment under a variety of conditions. However, if the modeled attainment test shows that some peak concentrations are close to the standard, MAG will conduct additional tests, as described below.

5. SUPPLEMENTAL ANALYSES

When future design values are very close to the standard, EPA recommends that corroboratory tests be performed [12]. If future design values in 2008 exceed 80 ppb, MAG will conduct additional analyses to confirm that attainment of the NAAQS for eight-hour ozone is likely to occur. If the corroboratory tests fail to support the finding of attainment, a weight of evidence approach may be applied. These supplemental analyses are discussed below.

5.1 Corroboratory Tests

EPA recommends that a supplemental screening test be applied in areas where the ozone monitoring network just meets or minimally exceeds the size of the network required to report data to the Air Quality System (AQS) [12]. The ozone monitoring network in the MNA includes more than twenty monitors, which exceeds the minimum requirement for AQS. However, as a corroboratory test, MAG will conduct the EPA-recommended screening test.

5.1.1 Screening Test

The screening test is intended to ensure that ozone will not exceed the standard in locations that are not near (i.e., in the 7 x 7 array surrounding) a monitor. This test requires the identification of areas in the nonattainment area where predicted eight-hour

daily maximum ozone concentrations are “consistently greater” than any predicted in the vicinity of a monitoring site. For each identified area, a location-specific RRF is multiplied times an appropriate current design value to estimate a future design value. If the resulting estimates are less than or equal to 84 ppb at all locations, the screening test is passed.

To identify “consistently greater” grid cells, EPA recommends “flagging” grid cells in the MNA for which the predicted eight-hour daily base case maxima is higher than any predicted maxima near a monitored location on 25 percent or more of the modeled base case days. A 7 x 7 array of grid cells will be constructed around each cell flagged by the screening test. If any of these grid cells show up within an array on 25 percent or more of the modeled days in the same episode, a future design value will be estimated for that cell.

For each flagged cell, the design value will be estimated by multiplying the modeled RRF by the current design value at the closest monitor. Alternatively, spatial interpolation may be performed to estimate the current design values of flagged cells.

5.1.2 Absolute Model Forecasts

If CAMx is able to reproduce observed base case ozone concentrations with relatively little statistical error or bias, the absolute modeling results for the 2008 forecast may be useful in corroborating the results using RRFs. Metrics that compare future year and base case modeled ozone concentrations might include:

- Percent change in total amount of ozone greater than or equal to 85 ppb in the MNA;
- Percent change in number of grid cells greater than or equal to 85 ppb in the MNA;
- Percent change in grid cell hours greater than or equal to 85 ppb in the MNA; and
- Percent change in maximum modeled eight-hour ozone concentration in the MNA.

5.1.3 Other Corroboratory Tests

MAG will perform other tests to confirm and explain the results of the CAMx modeling. The CMAQ model will be applied to corroborate the CAMx results. Other corroboratory tests may include applying the photochemical source apportionment tool in CAMx to determine which sources are contributing to attainment during the worst-case episode period in 2008.

5.2 Weight of Evidence Approach

If the modeling analyses fail to show attainment of the eight-hour ozone standard in 2008, EPA allows a weight of evidence approach to be applied. Past analyses have shown that future design value uncertainties of 2-4 ppb can result from use of alternate, but equally appropriate, emissions inventories, chemical mechanisms, and meteorological inputs [12]. The end product of a weight of evidence determination is a document which describes the analyses performed, the data bases used, key assumptions and outcomes, and why the evidence, viewed as a whole, supports a conclusion that the area will attain the NAAQS despite model-predicted future design values of 85 to 89 ppb.

If modeled future design values exceed 84 ppb, MAG will confer with Region IX EPA and the Air Quality Planning Team to design appropriate weight of evidence tests. It is not anticipated that this will be necessary, because the base case design values are close to the standard and additional reductions in ozone precursor emissions (i.e., Tier 2 and heavy duty diesel vehicle emission controls) are expected to occur by 2008.

6. PROCEDURAL REQUIREMENTS

The following items will be delivered in draft form to the EPA regional office for review and comment during the modeling study. MAG will also provide draft versions of these items to the Air Quality Planning Team for review and comments.

- The modeling protocol.
- The Technical Support Document which addresses the entire modeling analysis, including MM5 and CAMx input preparation and application and the attainment demonstration.

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